JC07 Rec'd PCT/PTO 15 FEB 2002

FORM PTO 1390 (REV. 11-2000)	U S DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE	ATTORNEY DOCKET NUMBER
	TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371	825-162
		U S APPLICATION NO (if known, see 37 CFR 1 5) 10/049732

INTERNATIONAL APPLICATION NO.	INTERNATIONAL FILING DATE	PRIORITY DATE CLAIMED
PCT/EP00/08085	08/18/2000	08/18/1999

TITLE OF INVENTION
AXIAL PISTON DRIVE WITH A CONTINUOUSLY ADJUSTABLE PISTON STROKE

APPLICANT(S) FOR DO/EO/US
OTFRIED SCHWARZKOPF

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. ☐ This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2. ☐ This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.
3. ☐ This is an express request to begin national examination procedures (35 U.S.C. 371(f)). The submission must include items (5), (6), (9) and (21) indicated below.
4. ☐ The US has been elected by the expiration of 19 months from the priority date (Article 31).
5. ☐ A copy of the International Application as filed (35 U.S.C. 371(c)(2))
   a. ☐ is attached hereto (required only if not communicated by the International Bureau).
   b. ☐ has been communicated by the International Bureau.
   c. ☐ is not required, as the application was filed in the United States Receiving Office (RO/US).
6. ☒ A English language translation of the International Application as filed (35 U.S.C. 371(c)(2)).
   a. ☒ is attached hereto.
   b. ☐ has been previously submitted under 35 U.S.C. 154(d)(4).
7. ☐ Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371(c)(3))
   a. ☐ are attached hereto (required only if not communicated by the International Bureau).
   b. ☐ have been communicated by the International Bureau.
   c. ☐ have not been made; however, the time limit for making such amendments has NOT expired.
   d. ☐ have not been made and will not be made.
8. ☐ A English language translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).
9. ☐ An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)).
10. ☐ A English language translation of the annexes of the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).

Items 11 to 20 below concern other document(s) or information included:

11. ☐ An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
12. ☐ An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
13. ☒ A FIRST preliminary amendment.
14. ☐ A SECOND or SUBSEQUENT preliminary amendment.
15. ☐ A substitute specification.
16. ☐ A change of power of attorney and/or address letter.
17. ☐ A computer-readable form of the sequence listing in accordance with PCT Rule 13ter.2 and 35 U.S.C. 1.821-1.825.
18. ☐ A second copy of the published international application under 35 U.S.C. 154(d)(4).
19. ☐ A second copy of the English language translation of the international application under 35 U.S.C. 154(d)(4).
20. ☒ Other items or information:
    ☐ Applicant claims small entity status.
    ☒ Supplement to Transmittal Letter.

U.S. APPLICATION NO. (if known, see 37 CFR 1.5)	INTERNATIONAL APPLICATION NO.	ATTORNEY'S DOCKET NUMBER
10/049732	PCT/EP00/08085	825-162

21. ☐ The following fees are submitted:		CALCULATIONS PTO USE ONLY
Basic National Fee (37 CFR 1.492(a)(1)-(5)):		
Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO and International Search Report not prepared by the EPO or JPO.....	$ 1,040.00	
International preliminary examination fee (37 CFR 1.482) not paid to USPTO but International Search Report prepared by the EPO or JPO.....	$ 890.00	
International preliminary examination fee (37 CFR 1.482) not paid to USPTO but international search fee (37 CFR 1.445(a)(2)) paid to USPTO	$ 740.00	
International preliminary examination fee (37 CFR 1.482).paid to USPTO but all claims did not satisfy provisions of PCT Article 33(1)-(4)..	$ 710.00	
International preliminary examination fee (37 CFR 1.482) paid to USPTO but all claims satisfied provisions of PCT Article 33(1)-(4).....	$ 100.00	
ENTER APPROPRIATE BASIC FEE AMOUNT =		$890.00

Surcharge of $130.00 for furnishing the oath or declaration later than ☐ 20 ☒ 30 months from the earliest claimed priority date (37 C.F.R. 1.491(3)).		+130.00	
CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE
Total Claims	11 - 20 =		x $ 18.00
Independent Claims	1 - 3 =		x $ 84.00
MULTIPLE DEPENDENT CLAIM(S) (if applicable)			+ $280.00
TOTAL OF ABOVE CALCULATIONS =		$1020.00	
☐ Applicant claims small entity status. See 37 CFR 1.27. The fees indicated above are reduced by 1/2.		-	
SUBTOTAL =		$1020.00	
Processing fee of $130.00 for furnishing the English Translation later than ☐ 20 ☐30 months from the earliest claimed priority date (37 C.F.R. 1.492(f)).		+	
TOTAL NATIONAL FEE =		$1020.00	
Fee for recording the enclosed assignment (37 C.F.R. 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 C.F.R. 3.28, 3.31). **$40.00** per property		+	
TOTAL FEES ENCLOSED =		$1020.00	
		Amount to be refunded:	
		Charged:	

a. ☒ A check in the amount of $ 1020.00 to cover the above fees is enclosed.

b. ☐ Please charge my Deposit Account No. _____ in the amount of $_____ to cover the above fees. A duplicate copy of this sheet is enclosed.

c. ☒ The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. 01.2000. A duplicate copy of this sheet is enclosed.

d. ☐ Fees are to be charged to a credit card. **WARNING:** Information on this form may become public. **Credit card information should not be included on this form.** Provide credit card information and authorization on PTO-2038.

NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.

SEND ALL CORRESPONDENCE TO:
ANDRUS, SCEALES, STARKE & SAWALL, LLP
100 East Wisconsin Avenue, Suite 1100
Milwaukee, Wisconsin 53202
Phone: (414) 271-7590
Fax: (414) 271-5770

Gary A. Essmann 2-15-02
Signature Date

GARY A. ESSMANN 29,376
Name Reg. No.

U.S. APPLICATION NO. (if known, see 37 CFR 1.5) 10/049732	INTERNATIONAL APPLICATION NO. PCT/EP00/08085	ATTORNEY'S DOCKET NUMBER 825-162

CERTIFICATE OF EXPRESS MAIL

I hereby certify that this correspondence is being deposited with the United States Postal Service with sufficient postage as EXPRESS MAIL-POST OFFICE TO ADDRESSEE, in an envelope addressed to: BOX PCT, COMMISSIONER OF PATENTS AND TRADEMARKS, WASHINGTON, D.C. 20231 on the 15th day of February, 2002. Express Mail Label EL 812734014US.

GARY A. ESSMANN	29,376
Name	Reg. No.
Gary A. Essmann	2-15-02
Signature	Date

PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Application of:	) AXIAL PISTON DRIVE WITH A
	) CONTINUOUSLY ADJUSTABLE
OTFRIED SCHWARZKOPF	) PISTON STROKE

PRELIMINARY AMENDMENT

Milwaukee, Wisconsin 53202

Box Patent Application
Asst. Commissioner for Patents
Washington, D.C. 20231

Sir:

Prior to computing the filing fee in this application, kindly amend the above identified application, as follows. The filing fee is to be computed on the amended claims.

In the Specification:

Beginning at page 1, between the title and the first line of text, the specification has been amended as follows:

CROSS REFERENCE TO RELATED APPLICATION

The present application is the U.S. national stage application of International Application PCT/EP00/08085, filed August 18, 2000, which international application was published on February 22, 2001 as International Publication WO 01/12988 A1 in the German language. The International Application claims priority of German Patent Application 199 39 130.0, filed August 18, 1999.

Before the paragraph starting on line 15 of page 1, insert the following:

Such an axial piston drive is known, for example from the patent US 3,304,886.

It is also known that axial piston drive with a continuously adjustable piston stroke can be used in particular for air conditioners in motor vehicles, specifically as coolant condensers.

Delete the paragraph starting at line 15 of page 1.

Delete the paragraph starting on line 31 of page 1 and substitute therefor:

The output of the coolant condenser can be continuously adjusted by way of the speed of a drive motor and in an especially energetically favourable manner, in the case of axial piston drive, by way of the piston stroke. Known axial piston drive or axial piston condensers for vehicle air conditioners comprise a drive shaft operated by way of a pulley. within a crank chamber a swash plate is supported on the drive shaft so that it is unrotatably fixed and can be tilted by way of a joint. The swash plate drives at least one piston that can move within a cylinder. In order to absorb tractive and pressure loads, each such piston is connected to the swash plate by way of two hinge yoke, one at the bearing surface of the swash plate that faces the piston and the other at the surface that faces away. With their flat surfaces contacting the bearing surfaces of the swash plate, the hinge yoke run at full circumferential velocity with a superimposed radial movement, which results in an elliptical track. The hinge yoke are seated with their rounded surfaces in sphere shaped formed bearings of the pistons, within which there is comparatively little relative movement during operation.

In the Claims:

Claim 1 has been amended as follows:

1. Axial piston drive with a continuously adjustable piston stroke, which comprises a drive shaft (10, 12, 170) and a swash plate (16, 18, 174) disposed in a bearing seat (14) that is positioned at a first tilt angle (22) with respect to the longitudinal direction (20) and on which the swash plate (16, 18, 174) is supported within a crank chamber (24), with a bore of bearing (30) that is tiled by a second tilt angle (28) with respect to the perpendicular line (26) of the swash plate (16, 18, 174), said swash plate (16, 18, 174) being rotatable through a range of angles by means of a controller (32, 34) in order to adjust the piston stroke, and also comprises at least one piston (44, 46, 48, 50) movably disposed in a cylinder (36, 38, 40, 42) and connected to the swash plate (16, 18, 174) so as to be driven thereby,

characterized in that coupled to or superimposed upon the rotational movement from a maximal resulting tilt angle (52) to the minimal resulting tilt angle (54) is an axial stroke movement (56) of the swash plate (16, 18, 174) in the direction towards the piston (44, 46, 48, 50), and coupled to or superimposed upon the rotational movement from the minimal resulting tilt angle (54) to the maximal resulting tilt angle (52) is an axial stroke movement (116) of the swash plate in the direction away from the piston (44, 46, 48, 50).

Claim 4 has been amended as follows:

Axial piston drive according to claim 1,

characterized in that when turned through an angle of 180°, the swash plate (16, 18, 174) is shifted axially by a distance amounting to half a maximal piston stroke (60).

Claim 5 has been amended as follows:

Axial piston drive according to claim 1, characterized in that the swash plate (174) is rotatably seated in an axially sliding sleeve (178).

Claim 6 has been amended as follows:

Axial piston drive according to claim 1,

characterized in that the controller (32) comprises a counterforce mechanism with at least one prestressed torsion spring (62, 64, 66, 68) that acts on the swash plate (16, 174).

Claim 7 has been amended as follows:

Axial piston drive according to claim 1,

characterized in that the controller (34) comprises an adjustment unit (70) that is separate from the piston (44, 46, 48, 50).

Respectfully submitted,

Gary A. Essmann
(Reg. No. 29,376)

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(414) 271-7590
Atty. Docket No. 825-162

CERTIFICATE OF EXPRESS MAIL

I hereby certify that this correspondence is being deposited with the United States Postal Service, with sufficient postage, as EXPRESS MAIL - POST OFFICE ADDRESSEE, in an envelope addressed to: Commissioner for Patents, Washington, D.C. 20231 on the 15th day of February, 2002. The Express Label is EL812734014US.

Marlene Kubiak	
Name	Reg. No.
Signature	February 15, 2002 Date

VERSION WITH MARKINGS TO SHOW CHANGES MADE

Attorney Docket No. 825-162

In the specification:

Please add the following paragraph at page 1, between the title and the first line of text as follows:

CROSS REFERENCE TO RELATED APPLICATION

The present application is the U.S. national stage application of International Application PCT/EP00/08085, filed August 18, 2000, which international application was published on February 22, 2001 as International Publication WO 01/12988 A1 in the German language. The International Application claims priority of German Patent Application 199 39 130.0, filed August 18, 1999.

Before the paragraph starting on line 15 of page 1, insert the following:

Such an axial piston drive is known, for example from the patent US 3,304,886.

It is also known that axial piston drive with a continuously adjustable piston stroke can be used in particular for air conditioners in motor vehicles, specifically as coolant condensers.

Delete the paragraph starting at line 15 of page 1 as follows:

~~The use of axial piston drive with a continuously adjustable piston stroke is known in particular for motor vehicle air conditioners, where they serve as coolant condensers.~~

Paragraph starting on line 31 of page 1 has been amended as follows:

~~The output of the coolant condenser can be continuously adjusted by way of the speed of a drive motor and in an especially energetically favourable manner, in the case of axial piston drive, by way of the piston stroke. Known axial piston drive or axial piston condensers for vehicle air conditioners comprise a drive shaft operated by way of a pulley. Within a crank chamber a swash plate is supported on the drive shaft so that it is unrotably~~

~~fixed and can be tilted by way of a joint. The swash plate drives at least one piston that can move within a cylinder. In order to absorb tractive and pressure loads, each such piston is connected to the swash plate by way of two hinge yoke, one at the bearing surface of the swash plate that faces the piston and the other at the surface that faces away. With their flat surfaces contacting the bearing surfaces of the swash plate, the hinge yoke run at full circumferential velocity with a superimposed radial movement, which results in an elliptical track. The hinge yoke are seated with their rounded surfaces in sphere shaped formed bearings of the pistons, within which there is comparatively little relative movement during operation.~~

The output of the coolant condenser can be continuously adjusted by way of the speed of a drive motor and in an especially energetically favourable manner, in the case of axial piston drive, by way of the piston stroke. Known axial piston drive or axial piston condensers for vehicle air conditioners comprise a drive shaft operated by way of a pulley. within a crank chamber a swash plate is supported on the drive shaft so that it is unrotatably fixed and can be tilted by way of a joint. The swash plate drives at least one piston that can move within a cylinder. In order to absorb tractive and pressure loads, each such piston is connected to the swash plate by way of two hinge yoke, one at the bearing surface of the swash plate that faces the piston and the other at the surface that faces away. With their flat surfaces contacting the bearing surfaces of the swash plate, the hinge yoke run at full circumferential velocity with a superimposed radial movement, which results in an elliptical track. The hinge yoke are seated with their rounded surfaces in sphere shaped formed bearings of the pistons, within which there is comparatively little relative movement during operation.

In the claims:

Claim 1 has been amended as follows:

1. Axial piston drive with a continuously adjustable piston stroke, which comprises a drive shaft (10, 12, 170) and a swash plate (16, 18, 174) disposed in a bearing seat (14) that is positioned at a first tilt angle (22) with respect to the longitudinal direction (20) and on which the swash plate (16, 18, 174) is supported within a crank

chamber (24), with a bore of bearing (30) that is tiled by a second tilt angle (28) with respect to the perpendicular line (26) of the swash plate (16, 18, 174), said swash plate (16, 18, 174) being rotatable through a range of angles by means of a controller (32, 34) in order to adjust the piston stroke, and also comprises at least one piston (44, 46, 48, 50) movably disposed in a cylinder (36, 38, 40, 42) and connected to the swash plate (16, 18, 174) so as to be driven thereby,

characterized in that coupled to or superimposed upon ~~onto~~ the rotational movement from a maximal resulting tilt angle (52) to the minimal resulting tilt angle (54) ~~there~~ is ~~superimposed~~ an axial stroke movement (56) of the swash plate (16, 18, 174) in the direction towards the piston (44, 46, 48, 50), and coupled to or superimposed upon ~~onto~~ the rotational movement from the minimal resulting tilt angle (54) to the maximal resulting tilt angle (52) ~~there~~ is ~~superimposed~~ an axial stroke movement (116) of the swash plate in the direction away from the piston (44, 46, 48, 50).

Claim 4 has been amended as follows:

Axial piston drive according to ~~one of the preceding claims~~ claim 1,

characterized in that when turned through an angle of 180°, the swash plate (16, 18, 174) is shifted axially by a distance amounting to half a maximal piston stroke (60).

Claim 5 has been amended as follows:

Axial piston drive according to ~~one of the claims 2 to 4~~ claim 1, characterized in that the swash plate (174) is rotatably seated in an axially sliding sleeve (178).

Claim 6 has been amended as follows:

Axial piston drive according to ~~one of the preceding claims~~ claim 1, characterized in that the controller (32) comprises a counterforce mechanism with at least one prestressed torsion spring (62, 64, 66, 68) that acts on the swash plate (16, 174).

Claim 7 has been amended as follows:

Axial piston drive according to ~~one of the preceding claims~~ claim 1, characterized in that the controller (34) comprises an adjustment unit (70) that is separate from the piston (44, 46, 48, 50).

7/pats

Axial piston drive with a continuously adjustable piston stroke

State of the art

The invention relates to an axial piston drive with a continuously adjustable piston stroke according to the characterizing clause of Claim 1.

The use of axial piston drive with a continuously adjustable piston stroke is known in particular for motor-vehicle air conditioners, where they serve as coolant condensers.

The main components of an air conditioner for a motor vehicle are a coolant condenser, a first heat exchanger, a so-called evaporator, a second heat exchanger, a so-called liquefier or gas cooler in the case of supracritical processes, an expansion organ and conduits that connect the components to one another. The role of the coolant condenser is to suck a coolant in from the evaporator, in which the coolant evaporates at a low pressure level under heat absorption, and to condense it at a higher pressure level. Subsequently, in the second heat exchanger, the coolant release the heat at a higher pressure and temperature level, and in the expansion organ it is returned to a pressure level corresponding to that of the evaporator. The result is a closed cyclic process.

The output of the coolant condenser can be continuously adjusted by way of the speed of a drive motor and in an especially energetically favourable manner, in the case of axial piston drive, by way of the piston stroke. Known axial

piston drive or axial piston condensers for vehicle air conditioners comprise a drive shaft operated by way of a pulley. Within a crank chamber a swash plate is supported on the drive shaft so that it is unrotably fixed and can be tilted by way of a joint. The swash plate drives at least one piston that can move within a cylinder. In order to absorb tractive and pressure loads, each such piston is connected to the swash plate by way of two hinge yoke, one at the bearing surface of the swash plate that faces the piston and the other at the surface that faces away. With their flat surfaces contacting the bearing surfaces of the swash plate, the hinge yoke run at full circumferential velocity with a superimposed radial movement, which results in an elliptical track. The hinge yoke are seated with their rounded surfaces in sphere shaped formed bearings of the pistons, within which there is comparatively little relative movement during operation.

Furthermore, the connection between the the swash plate and the piston can be formed not only by the above hinge yoke but in addition by way of a wobble plate. The wobble plate is secured against torsion with respect to the drive shaft by either a housing or piston rods. A bearing between the swash plate and the wobble plate absorbs the entire relative movement. The wobble plate performs only a wobbling movement as a result of the rotation of the swash plate.

The piston stroke and hence the output of the axial piston drive unit is adjusted by altering the tilt angle of the swash plate. A large tilt angle results in a long piston stroke and high output, whereas with a small tilt angle the piston stroke is shorter and the output lower. As a rule, the tilt angle of the swash plate is limited to a minimal and a maximal value by two stops. Ordinarily one or two guide pins are needed to guide the tilting movement in a specified manner and to avoid jamming. The tilt limiters, i.e. the stops, can be integrated into the guide pins.

If the adjustment of the tilt angle from a maximal value to a smaller one shifts a top-dead-centre point of the piston within the cylinder in the direction of the swash plate, already compressed gas cannot be completely expelled. The compression energy introduced into the gas cannot be utilized for the cooling process. The result is a "damage space" between the piston and a valve plate on the cylinder, which causes a loss of energy. In order to avoid the "damage space" and to preserve the top-dead-centre point of the piston, the swash plate is mounted so that it can additionally be axially displaced against a prestressed compression spring. The movement of the swash plate in the axial direction is usually limited by stopping devices.

Advantages of the invention

The axial piston drive in accordance with the invention comprises a drive shaft and a radial bearing seat for a swash plate that is oriented at a first tilt angle with respect to the longitudinal direction of the shaft. Mounted on the bearing seat is a swash plate within a crank chamber, with a bore of bearing that is tilted at a second angle with respect to the perpendicular line of the swash plate. The driving action of the swash plate is exerted by connection to at least one piston that can move within a cylinder. In order to permit adjustment of the tilt angle, and hence of the piston stroke and the output, the swash plate can be rotated on the bearing seat through a certain range of angles, by means of a controller.

It is proposed that onto the rotational movement from a maximal resulting tilt angle to a minimal resulting tilt angle there should be superimposed by an axial stroke movement of the swash plate in the direction towards the piston, and moves from the minimal resulting tilt angle to the maximal resulting tilt angle, it should superimposed by an axial stroke movement in the direction away from the piston. The moments of tilt acting on the swash plate can advantageously be supported by large

bearing surfaces on the drive shaft. Jamming is avoided and a long working life of the axial piston drive can be achieved. Furthermore, the axial stroke movement enables a damage space caused by the tilting movement to be avoided or minimized. The top-dead-centre point of the piston within the cylinder can be maintained, losses can be avoided and the axial piston drive can in particular be advantageously employed as a condenser in air conditioners. The condenser can be designed as a pure swash-plate condenser or as a wobble-plate condenser. Furthermore, the solution in accordance with the invention can be applied to gear mechanisms, hydraulic pumps and so on.

The axial stroke movement can be obtained by various methods that seem suitable to a person skilled in the art, for example by way of an axially moving piston or the like. It is particularly advantageous, however, to connect the swash plate to the drive shaft by means of a screw thread, which generates the additional axial stroke movement from the rotational movement of the swash plate. With little effort, by choosing a suitable screw pitch, a desired relationship between the rotational movement and the axial stroke movement can be produced. The screw pitch is advantageously made such that for a 180° angle of rotation the swash plate is shifted axially by half of a maximal piston stroke. The top-dead-centre point of the piston stays at the same position along the cylinder track and a damage space and energy losses are avoided.

Furthermore, the swash plate can be made especially insensitive to vibrations and impacts in both axial and radial directions, as well as to torque fluctuations, by an inhibition of the thread. The thread is preferably set into radial surfaces but can also be set into axial surfaces, for instance in the form of a ring wedge and a ring-wedge counterpart, etc. The thread can also be single or multiple. With a multiple-thread screw it can advantageously be ensured that despite a steep pitch, the swash plate at both minimal and maximal tilt angle is securely connected by the thread at the drive shaft at more than one

place around the circumference. The thread can also be set into an extra component attached to the drive shaft, for example an oblique cylinder. In one embodiment it is proposed that the thread be integrally formed in the drive shaft, for a saving in the number of additional components and the effort and expense of assembly. To enable an especially simple assembly and so that during the shifting process the centre of mass of the shifted parts can be displaced along a desired axis, in particular along the shaft axis, the swash plate is advantageously rotatably mounted on an axially displacable sleeve.

The controller comprises at least one adjustment unit, by means of which an adjustment force can be applied to tilt and axially displace the swash plate. The adjustment unit can be formed in part by the piston, in that by variation of a gas-pressure difference between the upper side of the piston and the lower side of the piston in the crank chamber an adjustment force is generated that shifts the swash plate against a counterforce device. The counterforce device can be formed by a compression spring or, advantageously, by a torsion spring that exerts a torque directly on the swash plate and hence can be incorporated more easily and perhaps more economically than a compression spring.

Furthermore, it is possible for the controller to comprise an adjustment unit separate from the piston, to shift the swash plate. With an adjustment unit that is separate from the piston the size of the range of control can be independent of the operating points. Flow losses between the upper side of the piston and the crank chamber can be reduced. Moreover, the axial piston drive can be operated with low pressure in the crank chamber. A leakage flow of coolant from the crank chamber and outwards through shaft seals is approximately proportional to the pressure in the crank chamber. With a slight pressure an elaborate sealing of the crank chamber can be eliminated and the leakage flow made smaller. This is advantageous in

particular in the case of coolants with high absolute pressures, for which in general high pressures in the crank chamber are needed to achieve control by way of a gas-pressure difference at the piston. With a low pressure, furthermore, the coolant of an air conditioner is only slightly soluble in a lubricant of the condenser, as a result of which a high viscosity can be maintained.

Another way in which a separate adjustment unit has a positive effect on viscosity is that heating of the lubricant by gas that has been warmed by the high-pressure side of the piston can be avoided. With a high viscosity, low friction between heavily loaded pairs of sliding elements on the swash plate and between the pistons and the cylinders can be achieved, which contributes to a long working life and a high degree of reliability.

With an adjustment unit separate from the piston, no particular pressure in the crank chamber is needed for control, as a result of which coolant can be conducted from an evaporator through the crank chamber into the cylinder. Therefore the crank chamber can be cooled, an additional suction chamber on the upper side of the piston can be avoided, and hence the whole structure occupies less space. Furthermore, it is usually possible to utilize a large volume of the crank chamber for the attenuation of gas pulsations.

The adjustment unit can be driven by electrical, pneumatic or preferably hydraulic means. With hydraulic fluid an advantageous damping of oscillation can be achieved and a particularly vibration-insensitive axial piston drive created. The adjustment unit can act directly on the swash plate, with a torque and/or with an axial adjustment force. An adjustment unit with an axial action can be particularly easily sealed off and economically constructed. In the case of an adjustment unit that exerts a torque on the swash plate, the controlling torgue acts directly in the direction of the rotational movement of

the swash plate, as a result of which the swash plate can be tilted and axially displaced with a small controlling torgue and a small, space-saving adjustment unit.

The hydraulic adjustment unit can be supplied with compressed oil by a hydraulic unit that is independent of the medium being propelled by the piston; for example, a hydraulic unit that is already present in a motor vehicle can advantageously be used for this purpose. Additional components can then be eliminated and a large range of control, independent of the operating points of the axial piston drive, can be attained. Furthermore, no build-up of pressure is needed for control when the axial piston drive is started up, for instance through a minimal tilt angle of 2°. A load-free starting of the axial piston drive is made possible, and it becomes easier to start for instance an internal combustion engine that powers the axial piston drive.

With an oil trap connected downstream of the condenser, on the high-pressure side, good heat transfer into the heat exchanger can be ensured and a high efficiency of an air conditioner achieved. Furthermore, the oil trap can be put to particularly good use if it supplies the hydraulic adjustment unit with pressurized oil. Pressure is applied to the oil from the oil trap depending on the operating point. If a large moment of displacement is required, the pressure in the oil trap is high; if only a small moment of displacement is needed, the pressure there is low.

In one embodiment it is proposed to connect the hydraulic adjustment unit to the crank chamber by way of a drain, which is a particularly useful arrangement in that the oil trap and the adjustment unit can be used to transport the lubricant back into the crank chamber. In this process, a flow from the oil trap to the adjustment unit and/or the drain from the adjustment unit to the crank chamber can be made controllable. The uncontrolled part is advantageously formed by a throttling site.

Drawing

Additional advantages will be apparent from the following description of drawings, which show exemplary embodiments of the invention. The drawings, the description and the claims contain numerous characteristics in combination. A person skilled in the art will be able also to consider the characteristics individually and to assemble them into other useful combinations.

The individual figures show the following:

Fig. 1 an axial piston drive with the piston at the maximal end of its stroke, in section;

Fig. 2 a section along the line II-II in Fig. 1;

Fig. 3 an axial piston drive according to Fig. 1 with the piston at the minimal end of its stroke, in section;

Fig. 4 a section along the line IV-IV in Fig. 3;

Fig. 5 an axial piston drive with a hydraulic adjustment unit;

Fig. 6 a section along the line VI-VI in Fig. 5;

Fig. 7 a schematic diagram of a form of hydraulic control, and

Fig. 8 part of a variant according to Fig. 2.

Description of the exemplary embodiments

Fig. 1 shows an axial piston drive for an air conditioner of a motor vehicle, which operates as a condenser. The axial piston

drive comprises a drive shaft 10 with bearing seat 14 for a swash plate 16, which is set at a first tilt angle 22 (Fig. 2) with respect to the longitudinal direction 20. When positioned on the bearing 14 within a crank chamber 24, the swash plate 16 is seated in a bore of bearing 30 that is tilted at a second angle 28 with respect to a perpendicular line 26 of the swash plate 16. With respect to its driving action, by way of hemispherical hinge yoke 78, 80, 82, 84, 86, 88, 90, 92 the swash plate 16 is connected to four pistons 44, 46, 48, 50 guided within cylinders 36, 38, 40, 42 (Figs. 3 and 4). To absorb tractive and pressure loads, each piston 44, 46, 48, 50 is connected to the swash plate 16 by two of the hinge yoke 78, 80, 82, 84, 86, 88, 90, 92, in such a way that one of the hinge yoke 78, 80, 82, 84, 86, 88, 90, 92 contacts the bearing surface 96 of the swash plate 16, faces towards the piston 44, 46, 48, 50, whereas the other hinge yoke contacts the bearing surface 94 of the swash plate 16, which faces away from the piston. The hinge yoke 78, 80, 82, 84, 86, 88, 90, 92 run, by way of their flat surfaces, along the bearing surfaces 94, 96 of the swash plate 16 with full circumferential velocity with superimposed radial movement, as a result of which an elliptical track is produced. The rounded surfaces of the hinge yoke 78, 80, 82, 84, 86, 88, 90, 92 are seated in sphere shaped formed bearings 98, 100, 102, 104, 106, 108, 110, 112 of the pistons 44, 46, 48, 50, within which there is comparatively little relative movement during operation.

So that the piston stroke and hence the ouput of the axial piston drive can be continuously adjusted, the swash plate 16 is made so that it can be rotated on the bearing seat 14 within a certain range of angles by means of a controller 32. When the bearing seat 14 and the bore of bearing 30 are tilted in the same direction, the tilt angles 22, 28 add up to a maximal resulting tilt angle 52 (Fig. 2); if the bearing seat 14 and the bore of bearing 30 are tilted in opposite directions, the tilt angles 22, 28 are subtracted, resulting in a minimal tilt angle 54 (Fig. 4). The minimal resulting tilt angle 54 amounts

to ca. 2°, so as to ensure that pressure will be built up when the axial piston drive is started.

In accordance with the invention, onto the rotational movement from the maximal resulting tilt angle 52 to the minimal resulting tilt angle 54 there is superimposed an axial stroke movement 56 of the swash plate 16 in the direction towards the pistons 44, 46, 48, 50, whereas onto the rotational movement from the minimal resulting tilt angle 54 to the maximal resulting tilt angle 52 there is superimposed an axial stroke movement 116 of the swash plate 16 in the direction away from the pistons 44, 46, 48, 50 (Figs. 1-4). The swash plate 16 is connected to the drive shaft 10 by a thread 58, which generates the supplementary stroke movement 56, 116 from the rotational movement of the swash plate 16. The thread 58 is integrally formed on the drive shaft 10 and its pitch is such that when the swash plate 16 rotates through 180°, it is displaced axially by a distance equal to half of a maximal piston stroke 60 and a top-dead-centre point 114 of the pistons 44, 46, 48, 50 remains at the same place within the cylinder track (Figs. 2 and 4). The stroke movement 56, 116 and the rotational movement of the swash plate 16 are limited by stops 120, 122 attached to the drive shaft 10, by which the drive shaft is supported 10 in the axial direction against a lid 162 and a housing 164 of the axial piston drive by way of thrust bearings 160 and thrust washers 168. Radially, the drive shaft 10 is seated by way of two radial bearings 166 in the cover 162 and in the housing 164.

The controller 32 comprises an adjustment unit formed in part by the pistons 44, 46, 48, 50. By variation of a gas-pressure difference between the upper side 118 of the pistons 44, 46, 48, 50 and the lower side of the pistons 44, 46, 48, 50 in the crank chamber 24, with channels and control valves not shown in detail here, an adjustment force is produced (Fig. 1) that displaces the swash plate 16 against a counterforce mechanism. The counterforce mechanism is formed by four pretensioned

torsion springs 62, 64, 66, 68. The torsion springs 62, 64, 66, 68 are supported against the stop plates 120, 122 of the swash plate 16 and act on the swash plate 16 by way of stops not shown in detail here. When the swash plate 16 is shifted from the maximal resulting tilt angle 52 to the minimal resulting tilt angle 54, the prestress of the torsion springs 62, 64, 66, 68 is increased. When the swash plate 16 is shifted from the minimal resulting tilt angle 54 to the maximal resulting tilt angle 52, the prestress of the torsion springs 62, 64, 66, 68 is reduced. Between the maximal and minimal resulting tilt angles 52, 54 the swash plate 16 can be continuously adjusted to any desired tilt angles. The swash plate 16 is displaced along a tilted central axis, as a result of which the swash plate is slightly eccentric when in the extreme positions. An umbalance in the extreme positions can advantageously be avoided by providing compensatory masses.

Fig. 8 shows part of a variant according to Fig. 1 with a drive shaft 170. On the drive shaft 170 a sleeve 178 is disposed so as to be axially displaceable and rotationally fixed. The sleeve 178 comprises a bearing seat 14 on which a swash plate 174 with a bearing hole 30 is rotatably mounted. The swash plate 174 is supported axially and radially on the sleeve 178 by way of antifriction bearings 182, 184, 186 and is coupled by way of a coupling 176 to a nut 180 that is connected to the drive shaft 170 by a screw thread 172. Regarding the adjustment function, the essential aspects will be evident from the description of the exemplary embodiment in Figs. 1 to 4. The major difference is that the swash plate 174 can be installed especially simply and, in addition, by appropriately configuring the sleeve 178 the centre of mass of the parts that are to be displaced can be guided along the axis of the shaft.

Figure 5 shows an axial piston drive with a controller 34 that comprises a hydraulic adjustment unit 70 separate from the pistons 44, 46, 48, 50. In the exemplary embodiments shown here, components that are substantially the same are

fundamentally identified by the same reference numerals. The adjustment unit 70 comprises a wheel with two vanes 128, 130 126 supported in a housing 124 (Fig. 6) which, in combination with two vanes 132, 134 on the housing 124, form four chambers 136, 138, 140, 142. In order to rotate a swash plate 18 on a drive shaft 12, the two chambers 142, 138 receive high oil pressure through an axial and a radial borehole 144, 146 in the drive shaft 12 and through a radial borehole 148 in the wheel 126. The wheel 126 is attached to the drive shaft 12, whereas the housing 124 can be rotated with respect to the wheel 126, exerts a torque on the swash plate 18 by way of a joining element 150, and displaces the swash plate 18 against the force exerted by the prestressed torsion springs 66, 68. The joining element 150 engages a recess 152 in the swash plate 18, can be shifted in the axial direction relative to the swash plate 18, and is in contact with the swash plate 18 over the entire range of displacement.

The adjustment unit 70 is provided through an influx 76 with compressed oil by an oil separator 72 disposed downstream of the cylinders 36, 38, 40, 42 and the adjustment unit 70 is connected to the crank chamber 24 by a drain 74 (Fig. 7). The coolant that has been separated from the oil is sent from the oil separator 72 to a low-pressure side of the air conditioning unit, as indicated by the arrow 154. The influx 76 running from the oil separator 72 to the adjustment unit 70 and the drain 74 from the adjustment unit 70, which runs to the crank chamber 24, are each controllable by a valve 156, 158. Furthermore, it would be possible to replace a valve 156 or 158 by a fixed throttling site.

List of reference numerals

	10	Drive shaft	78	Hinge yoke
	12	Drive shaft	80	Hinge yoke
	14	Bearing seat	82	Hinge yoke
5	16	Swash plate	84	Hinge yoke
	18	Swash plate	86	Hinge yoke
	20	Longitudinal direction	88	Hinge yoke
	22	Tilt angle	90	Hinge yoke
	24	Crank chamber	92	Hinge yoke
10	26	Perpendicular line	94	Bearing surface
	28	Tilt angle	96	Bearing surface
	30	Bore of bearing	98	Bearing
	32	Controller	100	Bearing
	34	Controller	102	Bearing
15	36	Cylinder	104	Bearing
	38	Cylinder	106	Bearing
	40	Cylinder	108	Bearing
	42	Cylinder	110	Bearing
	44	Piston	112	Bearing
20	46	Piston	114	Top dead centre
	48	Piston	116	Stroke movement
	50	Piston	118	Upper side
	52	Tilt angle	120	Stop
	54	Tilt angle	122	Stop
25	56	Stroke movement	124	Housing
	58	Thread	126	Wheel
	60	Piston stroke	128	Vane
	62	Torsion spring	130	Vane
	64	Torsion spring	132	Vane
30	66	Torsion spring	134	Vane
	68	Torsion spring	136	Chamber
	70	Adjustment unit	138	Chamber
	72	Oil separator	140	Chamber
	74	Drain	142	Chamber
35	76	Influx	144	Borehole

146	Borehole		168	Thrust washers
148	Borehole		170	Drive shaft
150	Joining element		172	Thread
152	Recess		174	Swash plate
154	Arrow		176	Coupling
156	Valve		178	Sleeve
158	Valve		180	Nut
160	Thrust bearing		182	Antifriction bearing
162	Lid		184	Antifriction bearing
164	Housing		186	Antifriction bearing
166	Bearing			

Claims

1. Axial piston drive with a continuously adjustable piston stroke, which comprises a drive shaft (10, 12, 170) and a swash plate (16, 18, 174) disposed in a bearing seat (14) that is positioned at a first tilt angle (22) with respect to the long itudinal direction (20) and on which the swash plate (16, 18, 174) is supported within a crank chamber (24), with a bore of bearing (30) that is tilted by a second tilt angle (28) with respect to the perpendicular line (26) of the swash plate (16, 18, 174), said swash plate (16, 18, 174) being rotatable through a range of angles by means of a controller (32, 34) in order to adjust the piston stroke, and also comprises at least one piston (44, 46, 48, 50) movably disposed in a cylinder (36, 38, 40, 42) and connected to the swash plate (16, 18, 174) so as to be driven thereby,
characterized in that onto the rotational movement from a maximal resulting tilt angle (52) to the minimal resulting tilt angle (54) there is superimposed an axial stroke movement (56) of the swash plate (16, 18, 174) in the direction towards the piston (44, 46, 48, 50), and onto the rotational movement from the minimal resulting tilt angle (54) to the maximal resulting tilt angle (52) there is superimposed an axial stroke movement (116) of the swash plate in the direction away from the piston (44, 46, 48, 50).

2. Axial piston drive according to Claim 1,
characterized in that the swash plate (16, 18, 174) is operatively connected to the drive shaft (10, 12, 170) by a screw thread (58, 172) that generates the supplementary axial stroke movement (56) from the rotational movement of the swash plate (16, 18, 174).

3. Axial piston drive according to Claim 2, characterized in that the thread (58, 172) is integrally formed on the drive shaft (10, 12, 170).

4. Axial piston drive according to one of the preceding claims, characterized in that when turned through an angle of 180°, the swash plate (16, 18, 174) is shifted axially by a distance amounting to half a maximal piston stroke (60).

5. Axial piston drive according to one of the claims 2 to 4, characterized in that the swash plate (174) is rotatably seated in an axially sliding sleeve (178).

6. Axial piston drive according to one of the preceding claims, characterized in that the controller (32) comprises a counterforce mechanism with at least one prestressed torsion spring (62, 64, 66, 68) that acts on the swash plate (16, 174).

7. Axial piston drive according to one of the preceding claims, characterized in that the controller (34) comprises an adjustment unit (70) that is separate from the piston (44, 46, 48, 50).

8. Axial piston drive according to Claim 7, characterized in that the adjustment unit (70) is hydraulically driven.

9. Axial piston drive according to Claim 8, characterized in that the hydraulic adjustment unit (70) is supplied with compressed oil by a hydraulic unit that is independent of the medium transported by the piston (44, 46, 48, 50).

10. Axial piston drive according to Claim 8, characterized in that the hydraulic adjustment unit (70) is supplied with compressed oil by an oil separator (72) disposed downstream of the cylinder (36, 38, 40, 42).

11. Axial piston drive according to Claim 10, characterized in that the hydraulic adjustment unit (70) is connected by way of a drain (74) to the crank chamber (24), and a influx(76) from the oil separator (72) to the adjustment unit (70) and/or the drain (74) from the adjustment unit (70) to the crank chamber (24) can be controlled.

Axial piston drive with a continuously adjustable piston stroke

Abstract

The invention is based on an axial piston drive with a continuously adjustable piston stroke, which comprises a drive shaft (10, 12, 170) and a swash plate (16, 18) mounted on a bearing seat (14) that is positioned at a first tilt angle (22) with respect to the longitudinal direction (20) and on which the swash plate (16, 18, 174) is supported within a crank chamber (24), with a bore of bearing (30) that is tilted by a second tilt angle (28) with respect to the perpendicular line of the swash plate (16, 18, 174), and in order to adjust the piston stroke the swash plate (16, 18, 174) can be rotated through a range of angles by means of a controller (32, 34), and also comprises at least one piston (44, 46, 48, 50) movably disposed in a cylinder (36, 38, 40, 42) and connected to the swash plate (16, 18, 174) so as to be driven thereby.

It is proposed that onto the rotational movement from a maximal resulting tilt angle (52) to the minimal resulting tilt angle (54) there is superimposed an axial stroke movement (56) of the swash plate (16, 18, 174) in the direction towards the piston (44, 46, 48, 50), and onto the rotational movement from the minimal resulting tilt angle (54) to the maximal resulting tilt angle (52) there is superimposed an axial stroke movement (116) of the swash plate in the direction away from the piston (44, 46, 48, 50).

(Fig. 2)

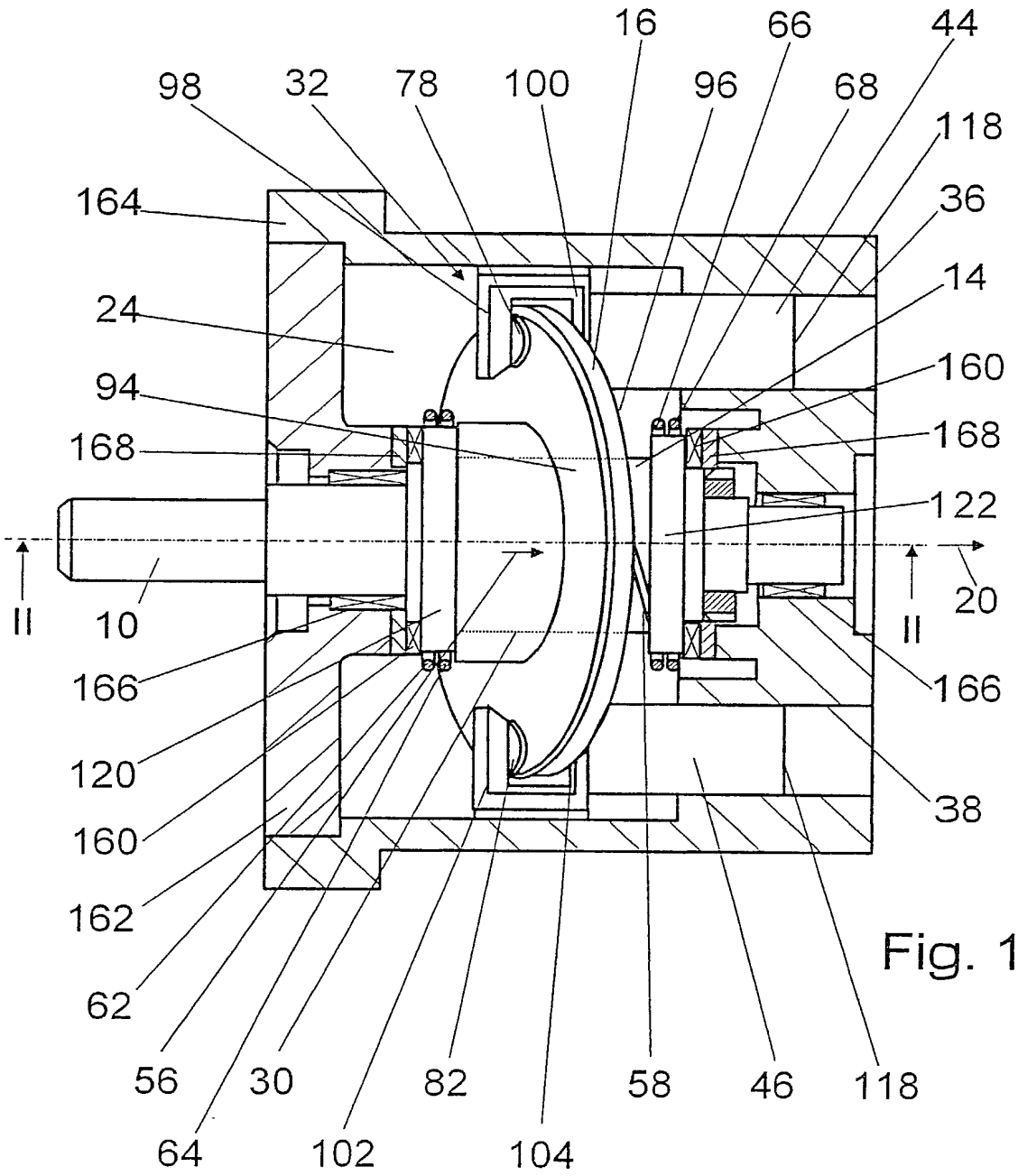
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Fig. 1

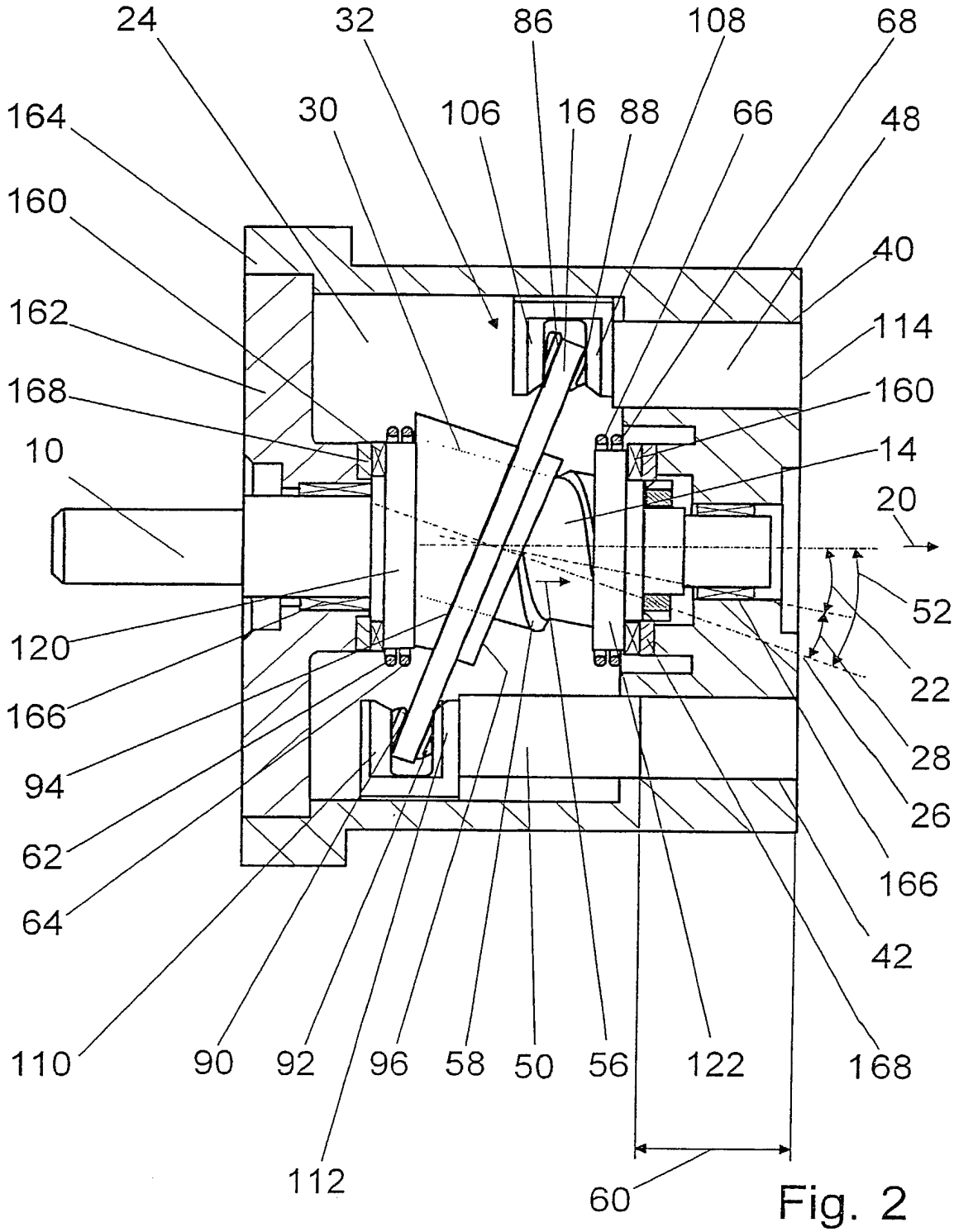
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Fig. 2

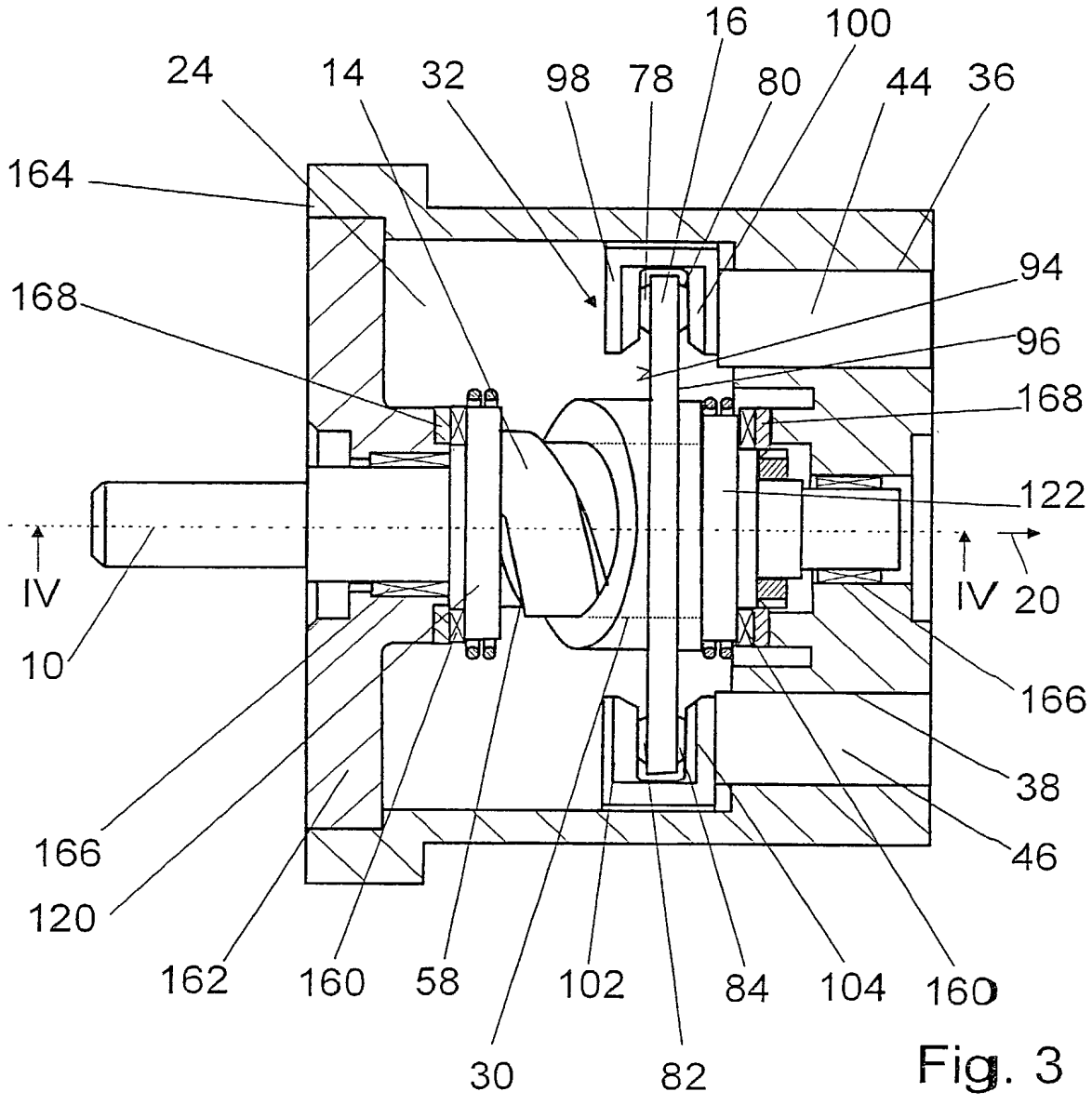
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Fig. 3

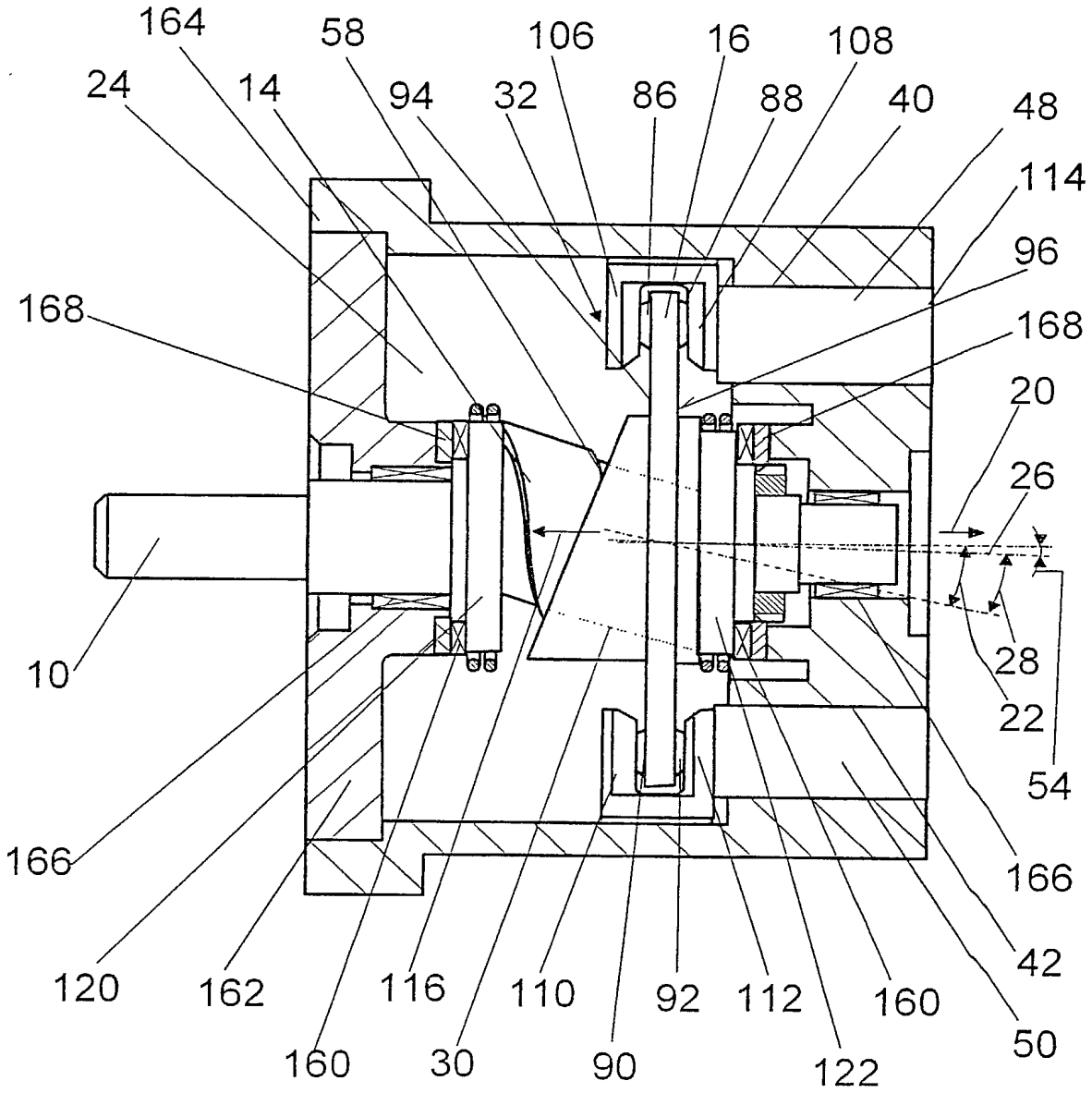
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Fig. 4

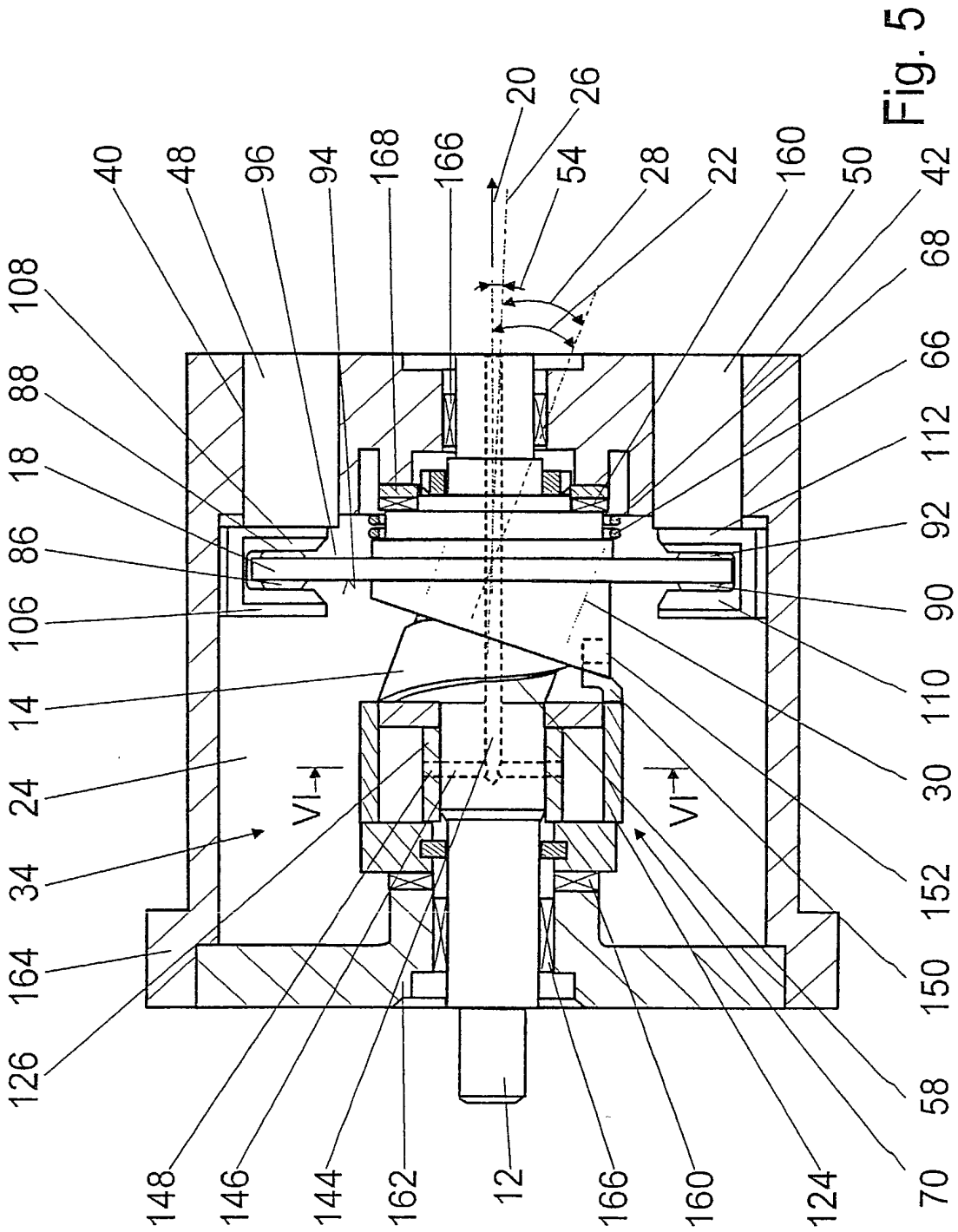
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Fig. 5

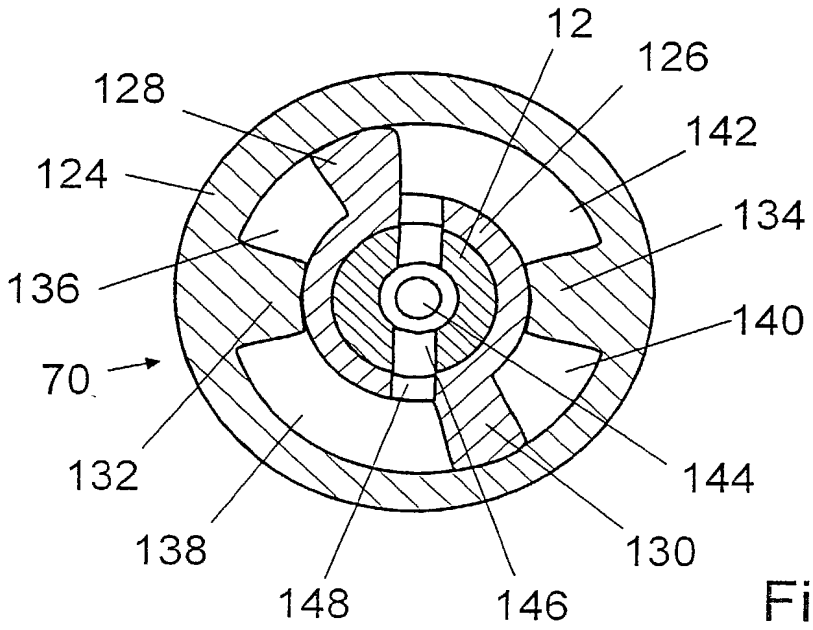
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Fig. 6

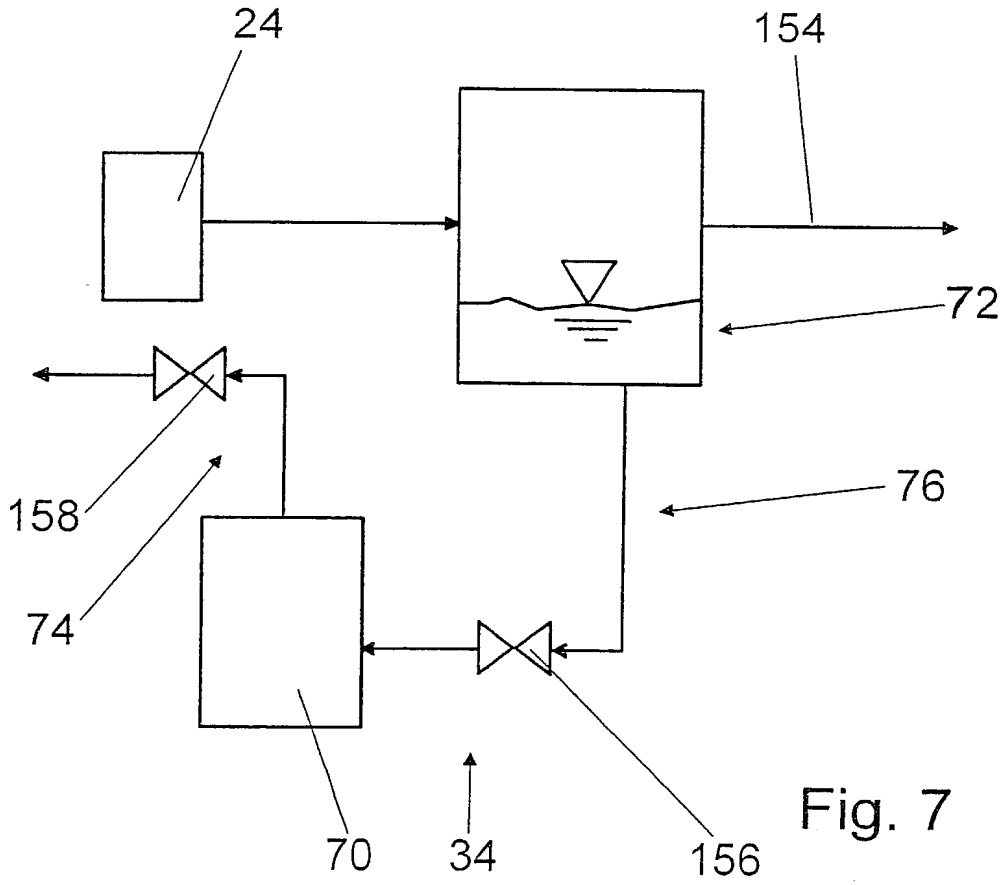
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Fig. 7

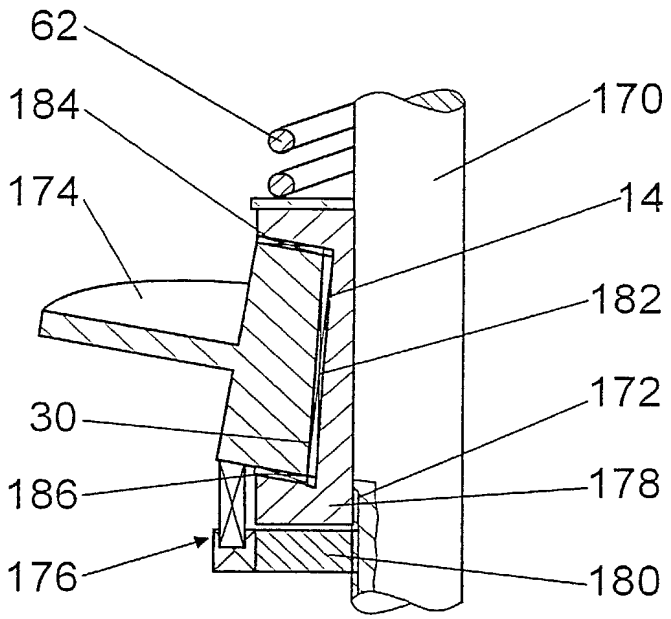

Fig. 8

(12) NACH DEM VERTRAG ÜBER DIE INTERNATIONALE ZUSAMMENARBEIT AUF DEM GEBIET DES PATENTWESENS (PCT) VERÖFFENTLICHTE INTERNATIONALE ANMELDUNG

(19) Weltorganisation für geistiges Eigentum
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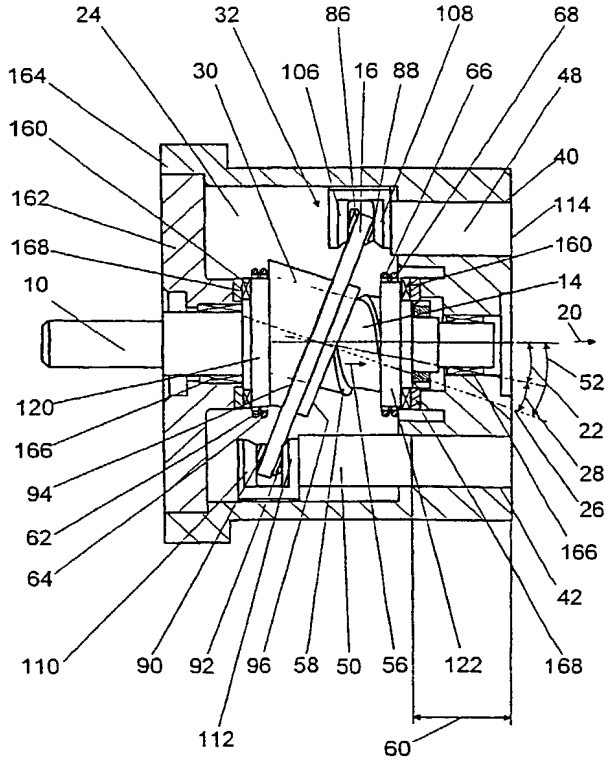
[Fortsetzung auf der nachsten Seite]

(54) **Title:** AXIAL PISTON DRIVE MECHANISM WITH A CONTINUOUSLY ADJUSTABLE PISTON STROKE

(54) **Bezeichnung:** AXIALKOLBENTRIEBWERK MIT EINEM STUFENLOS VERSTELLBAREN KOLBENHUB



lung des Kolbenhubs

(57) **Abstract:** The invention relates to an axial piston drive mechanism with a continuously adjustable piston stroke comprising an input shaft (10, 12, 170) and a bearing seat (14) for a swash-plate (16, 18) having a first tilting angle (22) in relation to the longitudinal direction (20), wherein the swash-plate (16, 18) is mounted in a crank chamber (24) with a bearing bore (30) which is tilted at a second tilting angle (28) relative to the perpendicular (26) of the swash-plate (16, 18, 174) and can be rotated around a tilting area with the aid of a regulating device to regulate the piston stroke. Said mechanism also comprises at least one piston (44, 46, 48, 50) that is drivingly connected to the swash-plate (16, 18, 174) and movable in a cylinder (36, 38, 40, 42). According to the invention, the rotational movement is shifted from a resulting maximum tilting angle (52) to a resulting minimum tilting angle (54) by an axial stroke (56) of the swash-plate (16, 18, 174) in the direction of the piston (44, 46, 48, 50) and from the resulting minimum tilting angle (54) to the maximum resulting tilting angle (52) by an axial stroke (116) in the direction opposite to the piston (44, 46, 48, 50).

(57) **Zusammenfassung:** Die Erfindung geht aus von einem Axialkolbentriebwerk mit einem stufenlos verstellbaren Kolbenhub, das eine Antriebswelle (10, 12, 170) und einen Lagersitz (14) für eine Schrägscheibe (16, 18) besitzt, der zur Längsrichtung (20) einen ersten Kippwinkel (22) aufweist, auf dem die Schrägscheibe (16, 18, 174) in einem Kurbelraum (24) mit einer zur Senkrechten (26) der Schrägscheibe (16, 18, 174) um einen zweiten Kippwinkel (28) gekippten Lagerbohrung (30) gelagert und zur Einstel-

[Fortsetzung auf der nächsten Seite]

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Approved for use through 9/30/00
Patent and Trademark Office: U.S. DEPARTMENT OF COMMERCE

PTO/SB/01
(8/96)

DECLARATION

Declaration ☐ Submitted with Initial Filing OR Declaration ☒ Submitted after Initial Filing

Attorney Docket Number	825-162
First Named Inventor	Otfried Schwarzkopf
COMPLETE IF KNOWN	
Application Number	
Filing Date	
Group Art Unit	
Examiner Name	

As a below named inventor, I hereby declare that:

My residence, post office address, and citizenship are as stated below next to my name.

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled:

AXIAL PISTON DRIVE WITH A CONTINUOUSLY ADJUSTABLE PISTON STROKE

(Title of the Invention)

the specification of which
☐ is attached hereto

OR

☒ was filed on (MM/DD/YYYY) [ ] as United States Application Number or PCT International Number [PCT/EP00/08085] and was amended on (MM/DD/YYYY) [ ] (if applicable).

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment specifically referred to above.

I acknowledge the duty to disclose information which is material to patentability as defined in Title 37 Code of Federal Regulations, §1.56.

I hereby claim foreign priority benefits under Title 35, United States Code §119(a)-(d) or §365(b) of any foreign application(s) for patent or inventor's certificate, or §365(a) of any PCT international application which designed at least one country other than the United States of America, listed below and have also identified below, by checking the box, any foreign application for patent or inventor's certificate, or of any PCT international application having a filing date before that of the application on which priority is claimed.

Prior Foreign Application Number(s)	Country	Foreign Filing Date (MM/DD/YYYY)	Priority Not Claimed	Copy Attached? YES	Copy Attached? NO
199 39 130.0	Germany	08/18/1999	☐	☐	☒
			☐	☐	☐
			☐	☐	☐
			☐	☐	☐
			☐	☐	☐

☐ Additional foreign application numbers are listed on a supplemental priority sheet attached hereto:

I hereby claim the benefit under Title 35, United States Code §119(e) of any United States provisional application(s) listed below.

Application Number(s)	Filing Date (MM/DD/YYYY)	
		☐ Additional provisional Application numbers are listed on a supplemental priority sheet attached hereto.

Type a plus sign (+) inside this box [+]

DECLARATION

I hereby claim the benefit under Title 35, United States Code §120 of any United States application(s), or §365© of any PCT international application designated the United States of America, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States of PCT International application in the manner provided by the first paragraph of Title 35, United States Code §112. I acknowledge the duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations §1.56 which became available between the filing date of the prior application and the national or PCT international filing date of this application.

U.S. Parent Application Number	PCT Parent Number	Parent Filing Date (MM/DD/YYYY)	Parent Patent Number (if applicable)

☐ Additional U.S. or PCT international application numbers are listed on a supplemental priority sheet attached hereto.

As a named inventor, I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and to transact all business in the Patent and Trademark Office connected therewith:

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George H. Solveson	25,927	Jeffrey S. Sokol	35,686
Gary A. Essmann	29,376	William L. Falk	27,709
Thomas M. Wozny	28,922		
Michael E. Taken	28,120		
Joseph J. Jochman, Jr.	25,058		

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Address	100 East Wisconsin Avenue, Suite1100						
City	Milwaukee	State	Wisconsin	Zip	53202-4178		
Country	United States	Telephone	(414) 271-7590	Fax	(414) 271-5770		

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under §1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Name of Sole or First Inventor: ☐ A petition has been filed for this unsigned inventor

Given Name (first and middle [if any])	Family Name or Surname
OTFRIED	SCHWARZKOPF

Inventor's Signature	Otfried Schwarzkopf				Date	29/05/02	
RESIDENCE: City	Magstadt	State		Country	Germany DEX	Citizenship	German
POST OFFICE ADDRESS	Maichinger Strasse 10						
City	Magstadt	State		Zip	D-71106	Country	Germany